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(71) Applicant (for all designated States except US): **EXCELSUS TECHNOLOGIES, INC.** [US/US]; 2875 Loker Avenue East, Carlsbad, CA 92008 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **KIKO, Frederick, J.** [US/US]; 3561 Donna Drive, Carlsbad, CA 92008 (US).

(74) Agent: **GAZDZINSKI, Robert, F.**; Gazdzinski & Associates, Suite 375, 11440 West Bernardo Court, San Diego, CA 92127 (US).

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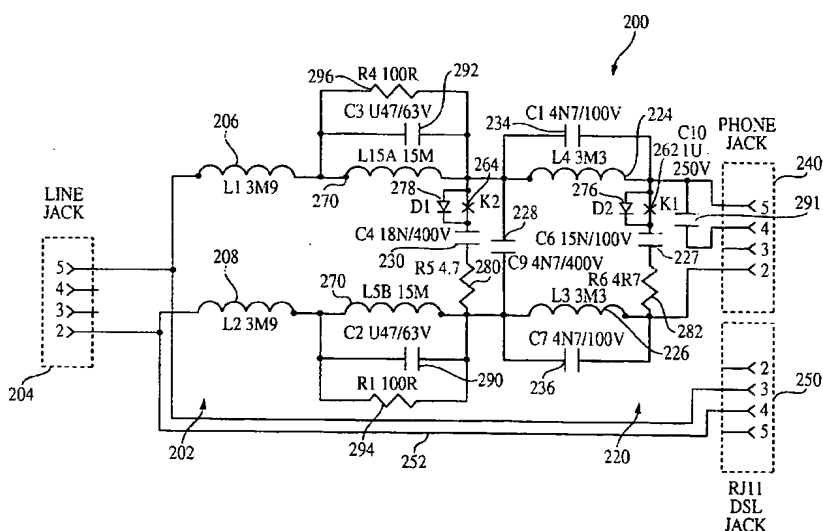
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(54) Title: HIGH PERFORMANCE MICRO-FILTER AND SPLITTER APPARATUS



(57) Abstract: Apparatus for conditioning and splitting telecommunications signals such as digital subscriber line (DSL) signals with improved stop band and return loss performance. In one aspect, the invention comprises an improved circuit having filter, impedance correction, and dynamic switching functionality suitable for more stringent application requirements (such as Europe). In one embodiment, the filter comprises a fourth-order elliptical filter coupled to an RLC impedance correction network. Dynamic switching is accomplished via a plurality of switch elements based on, e.g., filter current. In a second embodiment, a non-dynamic splitter with impedance correction and filter circuit is disclosed. Subscriber-end systems employing the foregoing signal conditioning and splitter circuits are also described.

**HIGH PERFORMANCE MICRO-FILTER AND SPLITTER APPARATUS**Background of the Invention1. Field of the Invention

5 The present invention relates generally to electronics used in telecommunications applications, and particularly to an improved filter and splitter apparatus and methods for use in a digital subscriber line (DSL) or similar telecommunications system.

2. Description of Related Technology

10 Today, Asymmetrical Digital Subscriber Line (ADSL) installations are mostly what is known as "self-install", or specifically where the subscriber installs a micro-filter or in-line phone filters on each telephone to isolate the phones (including faxes, answering machines, etc.) from the line and the ADSL signal path. Fig. 1 illustrates a typical installation of such in-line filters.

15 The self-installable micro-filter is a challenging design, largely because it must have sufficient stop band in the DSL band to protect and preserve DSL performance, but at the same time should also have negligible effect on the voice band performance.

Fig. 1a illustrates a typical prior art in-line filter configuration used in DSL applications. Such prior art filter designs, however, often do not satisfy some of the telecom  
20 customer's requirements for both return loss and DSL stop band. One significant problem is that the total capacitance required for the DSL stop band requirements also produce excessive side tone in the upper band of the telephones, a highly undesirable result. Furthermore, the return loss problem becomes worse as more micro-filters are added for each of the subscriber's phones.

25 United Kingdom (UK) and European filter circuit requirements are more stringent. One major challenge in this regard is providing the 30 KHz stop band while providing the very high voice band return loss.

Based on the foregoing, an improved apparatus and method for filtering digital subscriber line (DSL) signals is needed. Such improved apparatus and methods would (i) be  
30 readily installed and implemented by the subscriber, (ii) make use of existing telecommunications and/or power line infrastructure, (iii) provide enhanced stop band and return loss performance with no penalty on other aspects of circuit performance, and (iv) be compatible with and/or adaptable to a number of different applications and prevailing

telecommunications specifications, thereby providing, *inter alia*, maximum manufacturing flexibility.

### Summary of the Invention

5           The present invention satisfies the aforementioned needs by providing an improved digital subscriber line communications filter and splitter apparatus, and method of operating the same.

          In a first aspect of the invention, an improved in-line signal filter apparatus for use in telecommunications applications is disclosed. In one embodiment, the application  
10       comprises an asymmetric digital subscriber line (ADSL) and associated Telco wiring having a plurality of extension jacks, and the apparatus comprises one or more dynamic filter circuits interposed between the extension jacks (e.g., wall jack) and the subscriber's associated extension devices (telephone, answering machine, etc.). Each filter circuit comprises an input portion, impedance correction portion, and dynamic response portion. In  
15       one exemplary variant, the circuit comprises a fourth order filter with an input section comprising a plurality of series inductors, and an impedance correction portion comprising a plurality of parallel RLC networks disposed in parallel with the inductors. Dynamic circuit elements (e.g., reed switches which are magnetically coupled to one or more of the inductors in the circuit) are used to vary the configuration, and therefore response, of the  
20       circuit when the extension device state changes, such as in going from an "on hook" to "off hook" condition. For example, when the extension device goes off hook, the associated filter circuit dynamically increases its capacitance in relation to the other on hook extension devices, thereby providing enhanced signal performance. Additionally, to protect the dynamic circuit elements from ringing voltage, protective elements (e.g., Zener diodes or varistors) are employed in the circuit to clamp the voltage to an acceptable level.  
25

          In a second aspect of the invention, the foregoing circuit is adapted to function as an improved signal splitter device for use in applications having master jack wiring. The splitter device includes the aforementioned input and impedance correction portions, yet without the dynamic portion of the circuit. The impedance correction portion, coupled with  
30       the higher order (e.g., fourth order elliptical) filter, provides enhanced splitter performance as compared to existing prior art designs.

          In a third aspect of the invention, an improved method of conditioning telecommunications signals using a circuit such as that previously referenced is disclosed. In one embodiment, the method generally comprises: providing telecommunications signals

having both first and second components; filtering at least a portion of the signals; and dynamically varying the capacitance of the circuit based at least in part on the magnitude of current flowing through at least a portion of the circuit. In another embodiment, the method further comprises selectively adjusting the impedance of the circuit to alter the return loss of the signals, thereby enhancing circuit (and system) performance.

In a fourth aspect of the invention, a telecommunications system architecture incorporating the improved filter or splitter apparatus previously described is disclosed. In one embodiment, the system comprises (i) a telecommunications line having a plurality of extensions within the subscriber's site, and carrying voice and DSL components; (ii) a plurality of filter or splitter circuits interconnected with respective ones of the extensions; and (iii) a plurality of extension devices (e.g., telephones, answering machines, etc.) connected to respective ones of the filter circuits.

#### Brief Description of the Drawings

The features, objectives, and advantages of the invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings, wherein:

Fig. 1 is a block diagram of a typical prior art ADSL installation in a home or small business environment, including prior art micro-filters installed on multiple phone extensions.

Fig. 1a is a schematic of the prior art DSL micro-filters shown in Fig. 1.

Fig. 2 is a schematic of one exemplary embodiment of the dynamic micro-filter circuit of the present invention, adapted for use with a multi-terminal telecommunications jack and extension device.

Fig. 2a is a top plan view of a first embodiment of a dual winding inductor/reed switch device for use in the filter circuit of Fig. 2.

Fig. 2b is a side elevational view of the dual winding device of Fig. 2a.

Fig. 2c is an end view of a second embodiment of the dual winding inductor/reed switch device for use in the circuit of Fig. 2.

Fig. 2d is a side elevational view of the dual winding inductor device of Fig. 2c.

Fig. 3 is a schematic of a second embodiment of the filter circuit of the invention, adapted for use as a splitter in applications having with master jack wiring.

Figs. 4a – 4c are top, front, and rear plan views of one exemplary embodiment of a filter housing used in conjunction with the filter circuits of Figs. 2 and 3.

Fig. 5 is a block diagram illustrating one exemplary embodiment of the telecommunications system architecture of the invention, including dynamic filter circuits.

#### Detailed Description of the Preferred Embodiment

5 Reference is now made to the drawings wherein like numerals refer to like parts throughout.

As used herein, the term "signal conditioning" or "conditioning" shall be understood to include, but not be limited to, signal voltage transformation, filtering and noise mitigation, signal splitting, impedance control and correction, current limiting, capacitance control, and  
10 time delay.

It is noted that while portions of the following description is cast in terms of RJ-type connectors and associated modular plugs of the type well known in the telecommunications art, the present invention may be used in conjunction with any number of different connector types. Accordingly, the following discussion is merely exemplary of the broader concepts.

15 Additionally, the terms "site" and "subscriber's site" as used herein shall include any location (or group of locations) having telecommunications line service provided thereto, including without limitation residential houses, apartments, offices, and businesses.

Lastly, as used herein, the term "extension device" is meant to include any type of telecommunications device compatible with use on existing telecommunications lines,  
20 including without limitation conventional telephones, answering machines, facsimile machines, wireless or satellite receivers, and multi-line phones.

#### *Overview*

The present invention solves the problems of inadequate stop band and voice band  
25 performance on telecommunications lines by advantageously providing (i) a "dynamic" filter configuration which can change states dependent on the operating condition of the associated extension devices; and (ii) an impedance correction circuit which provides, *inter alia*, enhanced return loss performance. Specifically, in the case of a telecommunications line having voice and DSL signal components, when one of the phones on the line goes  
30 "off hook" (typically only one of the phones are off hook at any one time), the dynamic circuitry of the off hook filter increases its capacitance, while all the other "on hook" phones on the same line remain at a low capacitance relative to the off hook circuit. This dynamic capacitance feature is acceptable and compatible with existing applications, since the primary need for the enhanced DSL stop band corresponds to the off hook phone, and

the presence of the phone's polarity guard diode bridge. The DSL high-level up stream energy can over-drive this diode bridge in the off hook phones, and accordingly produce unwanted inter-modulation distortion. Therefore, enhanced DSL stop band is needed to prevent such over-drive condition. When the phone or other extension device is on hook, the diode bridge is removed from the circuit, and less filter DSL stop band attenuation is required. Very little capacitance can therefore be employed in the filter circuits associated with the on hook phones. This allows the off hook phone to have a comparatively larger capacitance, and thus the dynamic filter can have near splitter performance.

Additionally, the filter and splitter circuits of the present invention includes a novel impedance correction circuitry on the line side of the circuit in order to further improve the voice band return loss and the phone's side tone, and therefore support prevailing European telecommunications standards and objectives.

#### *Filter Circuit Description*

Referring now to Fig. 2, a first embodiment of the dynamic micro-filter configuration of the invention is described. It will be appreciated that while the embodiment of Fig. 2 comprises an exemplary design adapted to meet the requirements for use in the United Kingdom (UK), the dynamic filter of the present invention may be adapted for use in literally any application, such as that of Fig. 3 herein (adapted for use in Sweden), or other countries, through proper component selection and configuration. Such alternate applications and adaptations are readily determinable to those of ordinary skill based on the present disclosure, and accordingly are not described further herein.

It will further be appreciated that while the following discussion is cast in terms of a plurality of discrete electrical components (i.e., resistors, inductors, capacitors, switches, etc.) used to form a circuit, portions of the circuit may be rendered in the form of integrated components (such as integrated circuits) or other types of components having the desired functionality and electrical performance.

As shown in Fig.2, the filter circuit 200 generally comprises an input section 202 having a plurality of input terminals (line side jack) 204 and two input inductors 206, 208. An output section 220 comprises two additional inductors 224, 226 (L3 , L4) and three capacitors 227, 228, 230 (C4, C9, C6). The filter's input inductors (L1, L2) 206, 208 are connected to the line side jack 204, while the filter's capacitive output section 220 is connected to the filter's phone side jack 240. The line and phone side jacks 204, 240 a UK-type modular jack of the type commonly used in the United Kingdom, although it will be

recognized that other types of modular plugs and connectors may be substituted. The filter 200 further includes a DSL jack 250 that, in the illustrated embodiment, comprises and RJ-11 type DSL jack, although others may be substituted as well. The DSL jack 250 passes directly via electrical pathways 252 to the line side jack 204 (or plug) to provide a convenience DSL or home phone network (HPN) jack.

The basic filter provided by the circuit of Fig. 2 is a fourth-order elliptical low pass filter that consists of the two input inductors 206, 208 (L1, L2), two output section inductors 224, 226 (L3, L4), and three bridge capacitors 227, 228, 230 (C4, C9, and C6, respectively). The input inductors 206, 208 provide the required input inductance to prevent loading on the DSL circuit, while the two capacitors 234, 236 (C1, C7) in the output section 220 are added to the output inductors 224, 226 (L3, L4) to produce a resonance on the order of 30 KHz, although it will be appreciated that other resistance and capacitance values can be selected in order to obtain other resonance frequencies. Accordingly, the embodiment of Fig. 2 is a fourth-order elliptical filter which produces a sharp 30 KHz cut-off. The elliptical stop band feature allows the design to minimize the total capacitance to typically  $< 40 \text{ nF}$  (i.e.,  $< 40\text{E-}09 \text{ Farad}$ ), which minimizes the effect of the capacitance on the phone's voice band performance.

#### *Dynamic Components*

To make the filter 200 dynamic and allow for self-installation by the subscriber for multiple filters for each telephone, two reed switches 262, 264 (K1, K2) are added to remove most of the filter capacitance for the on hook (idle) phones. Both of the reed switches 262, 264 are, in the embodiment of Fig. 2, magnetically coupled to the dual inductor 270 (L5A), as described in U.S. Patent Nos. 6,181,777 and 6,212,259 entitled "Impedance Blocking Filter Circuit", issued January 30, 2001 and April 3, 2001, respectively, and assigned to Assignee hereof. Specifically, the reed switches 262, 264 are coupled to the dual inductor 270 by virtue of their physical proximity to the windings of the inductor, and therefore the magnetic field generated thereby.

Figs. 2a and 2b illustrate one exemplary configuration for a dual inductor/reed switch device 266 compatible with the circuit of Fig. 2 and incorporating the dual inductor 270 and reed switches 262, 264. The inductor/reed switch device 266 is formed of cylindrical housing 267 and contains the dual inductor 270 and the two reed switches 262, 264. It should be apparent to those skilled in the art that the dual inductor/reed switch device 266 can be replaced with two single inductor/switch units (not shown) so as to

render the same functionality. In the illustrated embodiment, the reed switches 262, 264 are disposed horizontally with their longitudinal axis substantially parallel with that of the bobbin 268. This configuration provides the aforementioned magnetic coupling between the windings of the inductor 270 and the switches to operate the latter. The device 266 of Figs. 2a-2b is selected to be actuated on a predetermined loop current threshold (e.g., approximately 6-16 mA). If the loop current threshold is too low, the reed switch(es) may chatter during operation of the circuit, and may thus shorten the useful life of the switch(es). On the other hand, if the loop current threshold is too high, then the amount of loop current may be insufficient to actuate the switch(es) in the worst case condition.

10 Figs. 2c and 2d illustrate a second embodiment of a dual winding inductor/reed switch device 266 according to the invention. In this embodiment, the reed switches 262, 264 are disposed centrally within the interior region of the windings. It will be appreciated to those of ordinary skill in the magnetic component arts that any number of different physical configurations for the dual inductor/reed switches may be used consistent with the circuit of Fig. 2. The foregoing embodiments are therefore merely illustrative of the broader concepts.

When no loop current flows (because the phone is on hook), there is no magnetic field from the dual inductor 270 and the reed switches 262, 264 are open, which removes the capacitors 227, 230 (C4 and C6) from the circuit. This reduces the total capacitance for each on hook filter from approximately 37.7 nF to only 4.7 nF in this embodiment. The 4.7nF value is the minimum capacitance necessary to force any on hook phone resonance below 30 KHz. Additionally, to protect the reed switches 262, 264 from the ringing voltage, power cross-voltages and lightning induced transient voltages, two Zener diodes 276, 278 (D1, D2) are included across the reed switches 262, 264 as shown in Fig. 2 to clamp the peak voltage to below 12 V. The single diodes 276, 278 of the illustrated embodiment work satisfactorily because the capacitors are in series with the diodes, and will self bias the single diode when AC signals are present. Alternatively, however, the foregoing diode arrangement may be replaced dual back-to-back 6-12 V Zener diodes, or even low capacitance varistors. The construction and selection of such components, consistent with the present aims of providing the minimum capacitance in the device, are well known in the electronics arts, and accordingly are not described further herein.

To protect the reed switches 262, 264 from switching current spikes through the C9 capacitor 228 and the C4 capacitor 227 (and the C1, C7 capacitors 234, 236) when the reed switches close, two resistors 280, 282 (R5, R6) are added in series with the C4 and C6

capacitors 226, 230 to limit the switching current to below the maximum current ratings of the switches. The resistance values of R5, R6 are chosen low enough so as not to significantly affect the filters stop band performance.

## 5 *Impedance Correction*

The foregoing dynamic components of the filter 200 are collectively insufficient to provide enough return loss improvement to meet the requirements of the European/UK Specifications previously described. To address this issue, the resonant impedance correction circuit made from the dual inductor 270 (L5A, L5B), parallel network capacitors  
10 290, 292 (C2, C3), and parallel network resistors 294, 296 (R4, and R1) further improves the voice band return loss up to 10 db by adding a positive phase impedance in the 2-3 KHz band. The dual inductor 270 (L5A, L5B) performs a dual purpose; in addition to driving the reed switches during off hook as previously described, the dual inductor 270 (in combination with the network capacitors C2, C3 290, 292) forms a differential resonance  
15 impedance in series with the line input. The parallel network resistors 294, 296 (R3, R4) limit this impedance to approximately 200 ohms at resonance, which limits the maximum insertion loss to an acceptable level (i.e., on the order of 2 db).

The circuit 200 of Fig. 2 is further provided with a 1 microfarad ringing capacitor 291 (C10) across pins 4 and 5 of the phone jack 240. Filters used in UK applications  
20 require such a capacitor for ringing some three-wire phone installations. It will be recognized, however, that this capacitor is optional depending on the particular application in which the filter circuit of the invention is used.

It is further noted that the circuit 200 embodiment of Fig. 2 advantageously uses separate inductive coils for the various circuit inductors 206, 208, 224, 226 (L1, L2, L3,  
25 L4) rather than, for example, the dual EP13 style inductor typically used in many prior art designs. This arrangement provides a longitudinal blocking impedance as well as differential impedances, which some applications (including for example, European telecommunications specifications) require. Traditional EP-based designs have effectively no longitudinal impedance, so an additional coil is required. The additional coil adds extra  
30 DC resistance, and to compensate for the added resistance, larger coils are often required, thereby increasing the cost and space requirements associated with the filter. In contrast, with the separate coils design of the present invention, it is not necessary to add a longitudinal coil or increase the size of the filter's inductors. In the illustrated embodiment, the dual bobbin, dual shielded inductors such as those manufactured by the Assignee hereof

can provide the aforementioned longitudinal impedance as well as providing magnetic field to drive the reed switches. The construction and operation of these dual bobbin, dual inductors is described in detail in the aforementioned application and as specifically set forth in preceding sections of this application. It will be recognized, however, that  
5 inductors/impedances other than the dual bobbin, dual shielded type previously referenced may be used with success in the circuit 200 of Fig. 2. For example, the aforementioned EP-type inductors could be substituted; however, the attendant disadvantages of added coil, DC resistance, and inductor coil size would be present.

Referring now to Fig. 3, a second embodiment of the improved micro-filter  
10 apparatus of the present invention is described. This second embodiment 300 is particularly useful in single splitter application also having master jack wiring, such as is currently in use in Sweden. As shown in Fig. 3, the line jacks 302 and phone jack 304 are configured to interface with the two-wire systems of Sweden (in contrast to the four-wire variants in the UK as embodied in the circuit 200 of Fig. 2). The 1 microfarad ringing capacitor 291 (C10)  
15 across pins 4 and 5 of the UK phone jack is also obviated in the present embodiment. Additionally, in the embodiment of Fig. 3, the reeds 262, 264 and diodes 276, 278 of the circuit 200 of Fig. 2 are removed and replaced with short circuits 306, 308. The non-dynamic filter 300 functions as a splitter, and is simply plugged into the master jack located in the house or other installation site as a self-install splitter. As previously described with  
20 respect to Fig. 2, the impedance correction portion 320 of the circuit produces a splitter with superior return loss performance.

### *Housing*

Referring now to Figs. 4a-4c, one embodiment of a filter housing adapted to receive  
25 the filter or splitter circuits 200, 300 of the present invention is described. The housing 400 comprises a polymeric base plate 402 (such as ABS plastic) and cover 404 which collectively form a cavity (not shown) within which the filter/splitter circuit 200, 300 is received. The circuit is disposed on a circuit board 403 received in the cavity and restrained by the base plate 402 and cover 404 when the housing is assembled. In the illustrated embodiment (adapted for  
30 UK installation), the housing 400 further includes a two- or four-terminal line side plug or jack 204, two or four-terminal phone side plug or jack 240, and RJ-11 DSL jack 250 disposed within respective apertures 410, 412, 414 formed in the front and rear sides 422, 424 of the housing cover 404. In the case of the circuit 300 of Fig. 3, the four-terminal jacks 204, 240 would be replaced with two-terminal jacks. Alternatively, the housing (and associated

filter/splitter circuit) could be configured with three RJ-11 jacks, two RJ-45 jacks and an RJ-11 DSL jack, or any number of other permutations apparent to those of ordinary skill.

The housing can be mounted in literally any orientation and configuration desired including, for example, as a wall-mounted unit, or as a "free floating" (i.e., un-mounted) in-line unit. It will further be recognized that the housing (and filter circuit) may be adapted as other configurations, such as dual jack housings, cord and multiple jack housings, or cord and single jack housings. The housings and/or filter/splitter circuits may be ganged as well. Additionally, other signal conditioning devices may be incorporated within the housing (whether electrically or physically interfaced with the aforementioned circuits or otherwise) if so desired, consistent with electrical noise and physical space limitations.

### *System*

Referring now to Fig. 5, a telecommunications architecture employing the filter(s) previously described herein is disclosed. As shown in Fig. 5, the improved architecture 500 comprises (i) a telecommunications line 502 adapted for carrying DSL and voice signals to one or more distant ends 504; (ii) a local (site) telecommunications infrastructure 506 comprising a plurality of extensions (jacks) 508 accessible by the subscriber; (iii) a plurality of filter (or splitter) circuits 501 electrically interfaced with respective ones of the jacks 508; and (iv) a plurality of extension devices 510 electrically interfaced with respective ones of the filter circuits 501. The illustrated extension devices 510 comprise a standard telephone 510a, telephone with answering machine 510b, facsimile machine 510c, personal computer (PC) 510d with DSL modulator/demodulator apparatus 540, and wireless interface 510e, although other types of devices and combinations may be used. The individual filter circuits 501 are housed in respective housings of the type shown in Fig. 4 herein, and are made self-installable by the subscriber, such as through use of modular jack connections between the extension jacks 508, filter circuits 501, and extension devices 510.

As previously described, in the case of the dynamic filter circuit 200 of Fig. 2, an off hook condition present on one of the extension devices 510a-c generates a loop current which alters the reed switch position, thereby elevating the effective capacitance seen at the telecommunications extension jack 508 associated with that extension device. This advantageously permits the off hook filter circuit to have near splitter performance.

It is also noted that for a non-master jack facility or home, distributed dynamic filters may be utilized.

While the above detailed description has shown, described, and pointed out novel features of the invention as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the device or process illustrated may be made by those skilled in the art without departing from the invention. The foregoing description is of the best mode presently contemplated of carrying out the invention. This description is in no way meant to be limiting, but rather should be taken as illustrative of the general principles of the invention. The scope of the invention should be determined with reference to the claims.

WHAT IS CLAIMED IS:

1. Telecommunications signal conditioning apparatus, comprising:  
first terminals adapted to interface with a first telecommunications line, said telecommunications line being adapted to carry signals having first and second  
5 components;  
second terminals adapted to interface with an extension device; and  
impedance correction apparatus in electrical communication with said first terminals and adapted to alter return loss with respect to said second component of said signals.
- 10 2. The apparatus of Claim 1, further comprising signal filter apparatus in electrical communication with said first and second terminals and said impedance correction apparatus.
3. The apparatus of Claim 2, wherein said filter apparatus comprises a fourth order elliptical filter.
- 15 4. The apparatus of Claim 2, further comprising a dynamic switching apparatus in electrical communication with at least said signal filter apparatus, said dynamic switching apparatus being adapted to selectively alter the configuration of said signal filter apparatus.
5. The apparatus of Claim 2, wherein said dynamic switching apparatus comprises a plurality of reed switches magnetically coupled to at least one circuit element  
20 within said signal filter apparatus.
6. The apparatus of Claim 4, wherein said selective alteration of the configuration of said signal filter apparatus is determined at least in part in response to electrical current flowing in said signal filter apparatus.
7. The apparatus of Claim 6, wherein said selective alteration of the configuration  
25 of said signal filter apparatus is determined at least in part in response to electrical current flowing in said signal filter apparatus.
8. The apparatus of any Claims 6 or 7, wherein said filter apparatus comprises a fourth order elliptical filter.
9. The apparatus of Claim 4, further comprising voltage protection apparatus, said  
30 protection apparatus being adapted to protect said dynamic switching apparatus from voltage transients present within said telecommunications signal conditioning apparatus.
10. The apparatus of Claim 9, wherein said voltage protection apparatus comprises a plurality of Zener diodes disposed in electrical parallel with respective ones of said dynamic switching apparatus.

11. The apparatus of Claim 2, wherein said impedance correction apparatus comprises at least one RLC parallel network.

12. The apparatus of Claim 11, wherein said at least one RLC network is adapted to generate a positive phase impedance in a predetermined signal band.

5 13. The apparatus of Claim 12, wherein said predetermined signal band comprises approximately 2-3 KHz.

14. The apparatus of Claims 2 or 4, further comprising a third set of terminals, said third set of terminals being in electrical communication with said first set of terminals and adapted to interface with a second telecommunications line, said second line being in data  
10 communication with an xDSL modulator/demodulator apparatus.

15. The apparatus of Claim 4, wherein said signal filter apparatus comprises a plurality of inductors, each of said inductors having a respective coil.

16. The apparatus of Claim 4, wherein said signal filter apparatus comprises a plurality of dual bobbin magnetically shielded inductors.

15 17. A method of conditioning a digital subscriber line (DSL) signal flowing through a circuit, comprising:

filtering at least a portion of said signal; and

selectively adjusting the impedance of said circuit to alter the return loss of said signal.

18. The method of Claim 17, further comprising controlling the capacitance of at  
20 least a portion of said circuit.

19. The method of Claim 18, wherein said act of controlling the capacitance comprises dynamically varying the capacitance based on the magnitude of current flowing through at least a portion of said circuit.

20. The method of Claim 19, wherein said act of dynamically varying comprises  
25 selectively opening and closing a plurality of switch elements disposed within said circuit.

21. The method of Claim 18, wherein said act of filtering comprises filtering said DSL signal using a fourth-order elliptical filter.

22. The method of Claim 17, wherein said act of adjusting the impedance comprises generating a positive phase impedance in a predetermined signal band.

23. The method of Claim 22, wherein said act of generating comprises generating  
30 a positive phase impedance in the 2-3 KHz signal band.

24. A method of conditioning a digital subscriber line (DSL) signal flowing through a circuit, comprising:

filtering at least a portion of said signal; and

dynamically varying the capacitance of said circuit based at least in part on the magnitude of current flowing through at least a portion of said circuit as part of said act of filtering.

25. The method of Claim 24, further comprising selectively adjusting the  
5 impedance of said circuit to alter the return loss of said signal.

26. The method of Claim 25, wherein said act of filtering comprises filtering said signal using a fourth order elliptical filter.

27. Signal splitter apparatus for use with telecommunications signals having at least first and second signal components, comprising:  
10 filter apparatus adapted to filter said telecommunications signals; and  
impedance correction apparatus in electrical communication with said input filter apparatus and adapted to control the return loss associated with said second component of said signals.

28. The signal splitter apparatus of Claim 27, wherein said filter apparatus  
15 comprises a plurality of inductors and capacitors arranged so as to produce fourth-order elliptical filtering of said signals.

29. The signal splitter apparatus of Claims 27 or 28, wherein said impedance correction apparatus comprises at least one RLC parallel network.

30. The apparatus of Claim 29, wherein said at least one RLC network is adapted  
20 to generate a positive phase impedance in a predetermined signal band.

31. The apparatus of Claim 28, wherein said plurality of inductors and capacitors comprise four inductors and three capacitors respectively, two of said four capacitors being disposed in serial within each of two parallel electrical pathways formed between line-side and extension-side terminals of said splitter apparatus, said three  
25 capacitors acting as bridge capacitors between said two electrical pathways.

32. A telecommunications subscriber-side system, comprising:  
a telecommunications line adapted to carry signals having first and second signal components, said line having a plurality of extensions;  
a plurality of signal conditioning apparatus each comprising:  
30 first terminals adapted to interface with respective ones of said extensions of said telecommunications line;  
second terminals adapted to interface with an extension device;  
signal filter apparatus in electrical communication with said first and second terminals; and

dynamic switching apparatus in electrical communication with at least said signal filter apparatus, said dynamic switching apparatus being adapted to selectively alter the configuration of said signal filter apparatus in response to current flowing through said filter apparatus; and

5 a plurality of extension devices in electrical communication with respective ones of said second terminals;

wherein said system is configured such that an off hook condition existing in at least one of said extension devices results in increased stop band performance with respect to said first component of said telecommunications signals.

10 33. The system of Claim 32, said signal conditioning apparatus further comprising impedance correction apparatus in electrical communication with said first terminals and adapted to alter return loss with respect to said second component of said signals.

34. A telecommunications subscriber-side system, comprising:

15 a telecommunications line adapted to carry signals having first and second signal components;

a plurality of signal conditioning circuits operatively coupled to said telecommunications line, each of said signal conditioning circuits having:

a filter circuit;

20 an impedance correction circuit adapted to control the return loss with respect to said second signal component; and

a dynamic switching circuit adapted to control the stop band loss with respect to said first component; and

a plurality of extension devices operatively coupled to said signal conditioning circuits.

25 35. The system of Claim 34, wherein said filter circuit comprises a fourth-order elliptical filter.

36. The system of Claim 35, wherein said impedance correction circuit comprises at least one RLC network disposed within said filter circuit.

37. A telecommunications subscriber-side system, comprising:

30 a telecommunications line adapted to carry signals having first and second signal components;

a plurality of signal splitter circuits operatively coupled to said telecommunications line, each of said splitter circuits having:

a higher-order filter circuit; and

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an impedance correction circuit adapted to control the return loss with respect to said second signal component; and

a plurality of extension devices operatively coupled to said signal conditioning circuits.

- 5           38.    The system of Claim 37, wherein said higher-order filter circuit comprises a fourth-order elliptical filter, and said impedance correction circuit comprises at least one RLC network disposed within said filter circuit.

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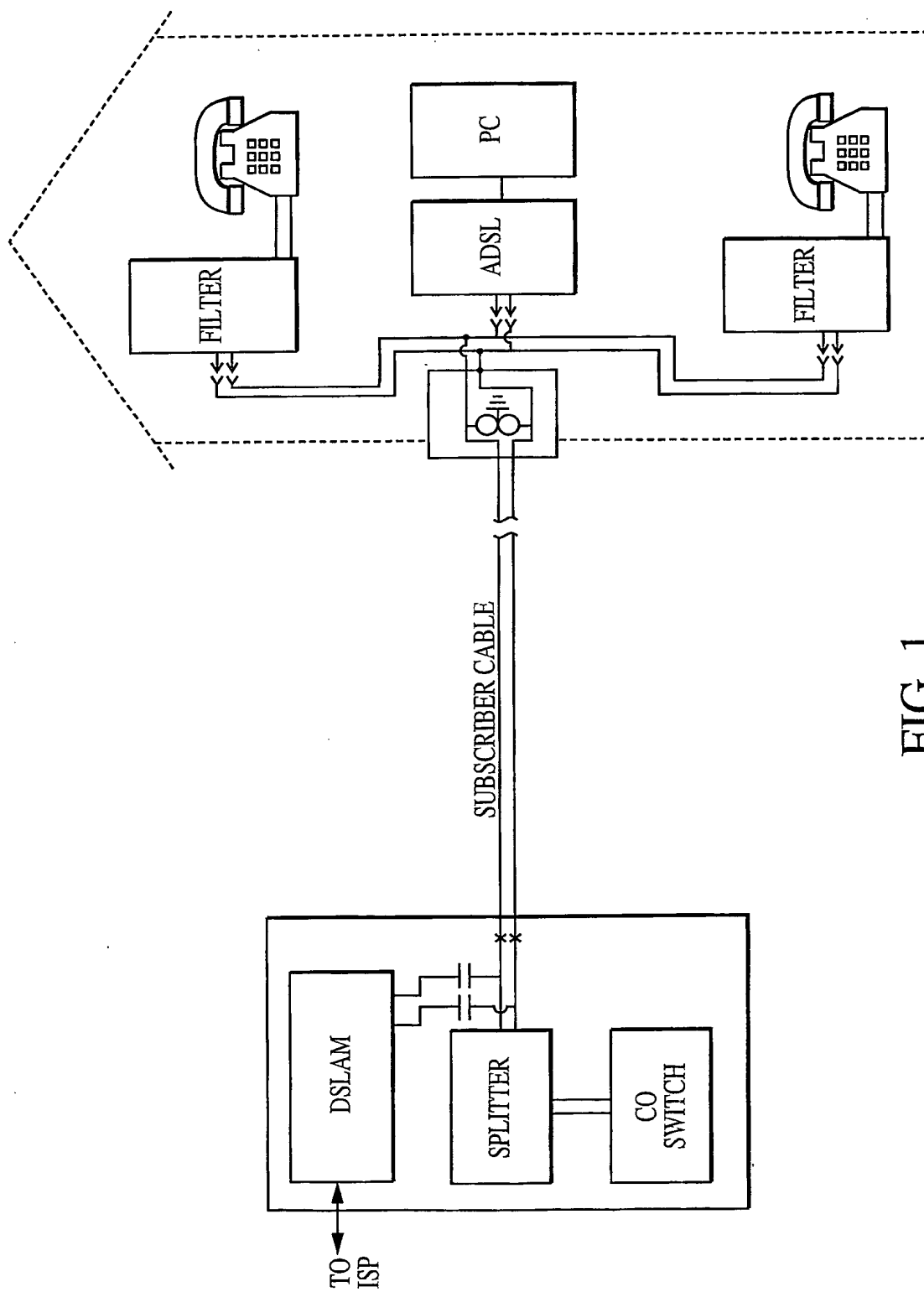


FIG. 1  
PRIOR ART

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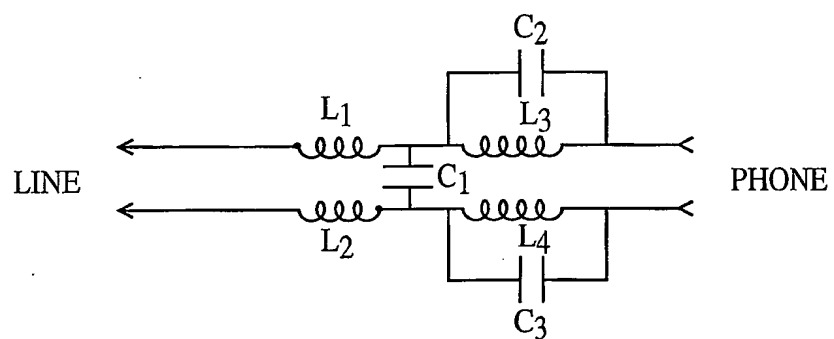


FIG. 1a  
PRIOR ART

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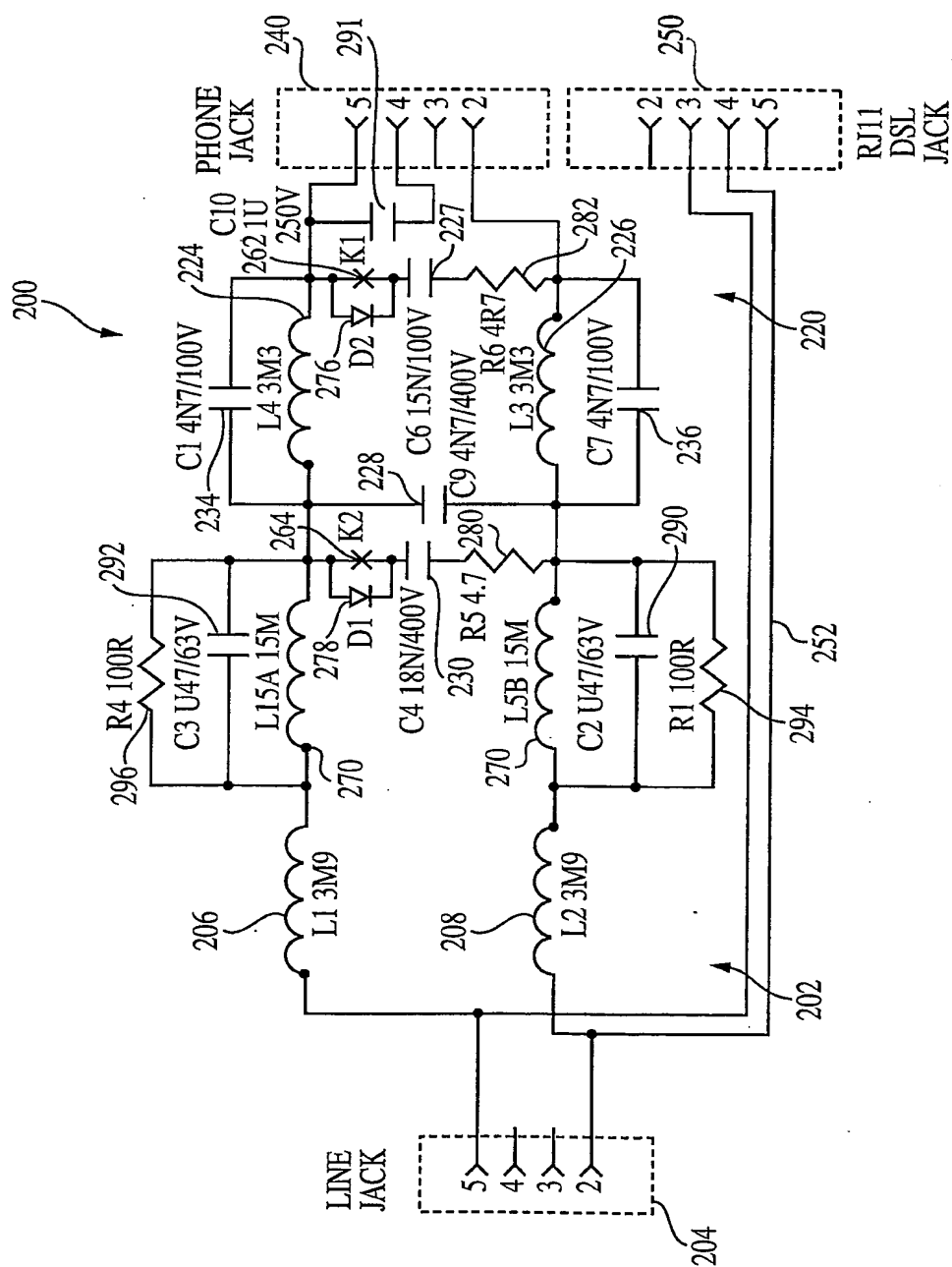


FIG. 2

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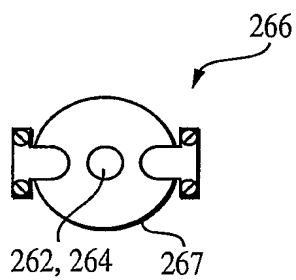


FIG. 2a

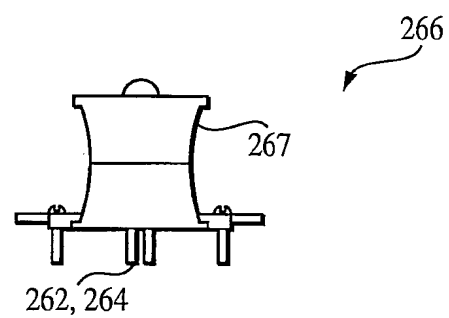


FIG. 2b

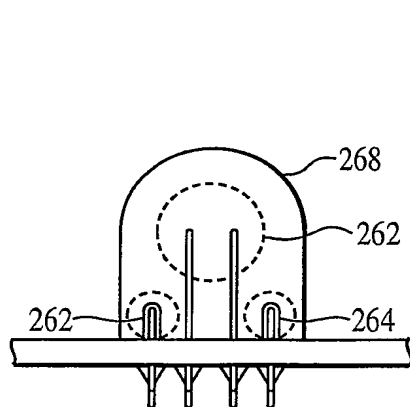


FIG. 2c

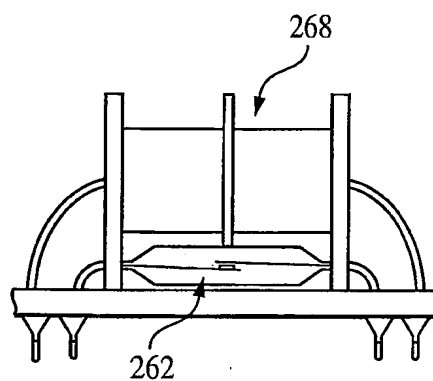


FIG. 2d

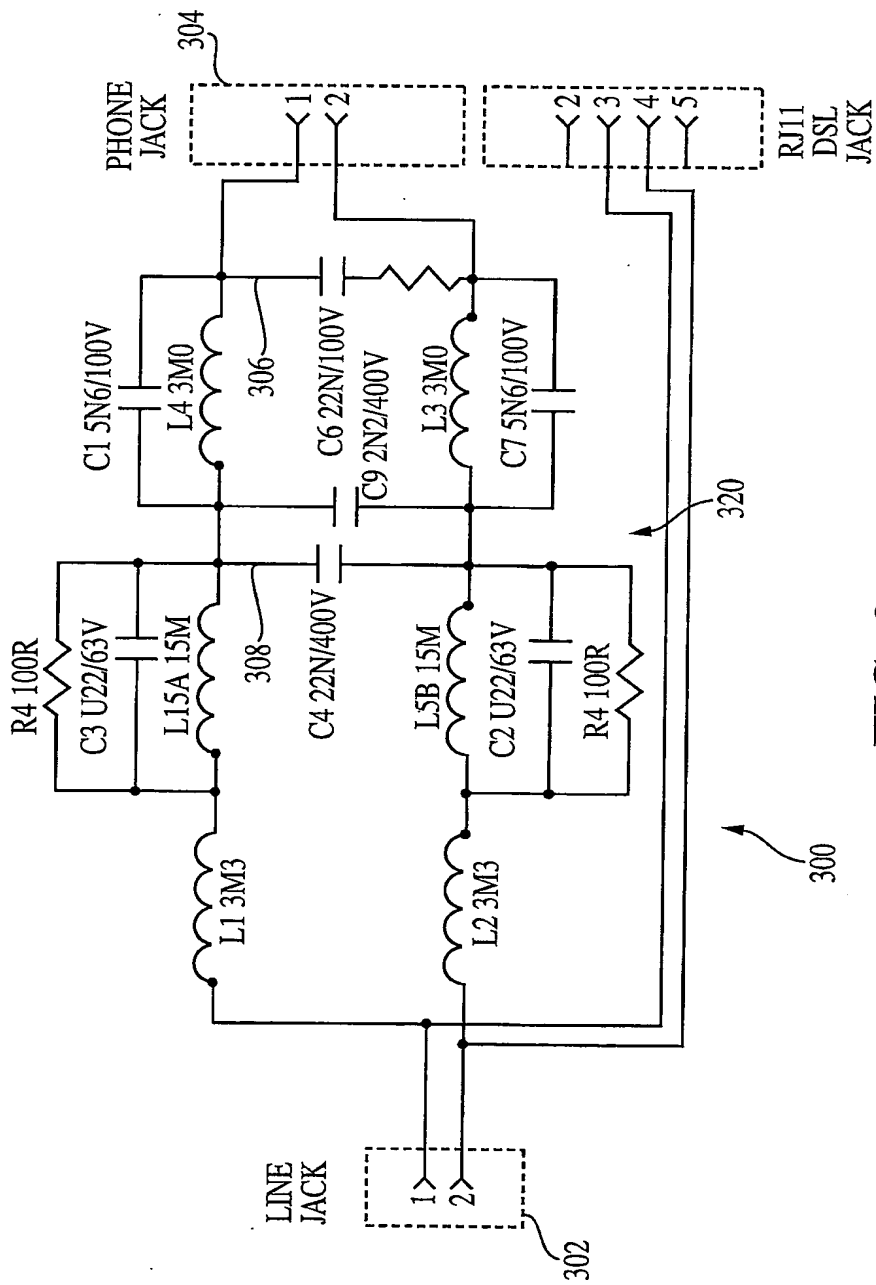


FIG. 3

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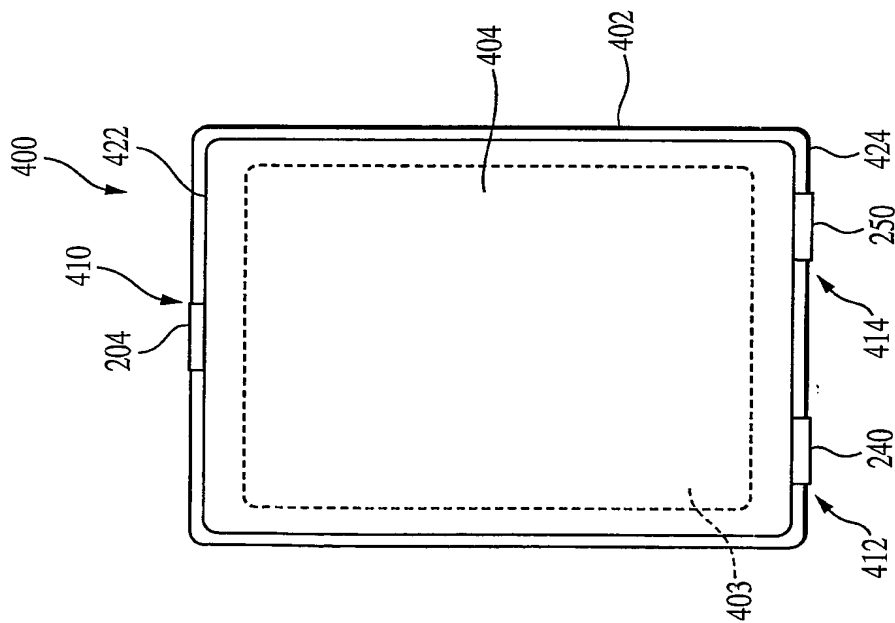


FIG. 4a

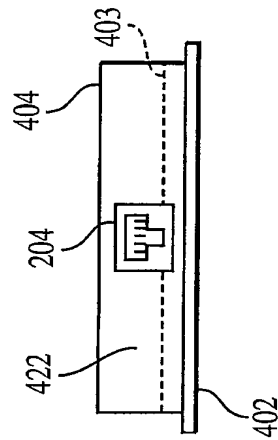


FIG. 4b

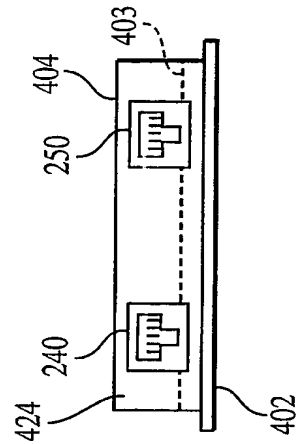


FIG. 4c

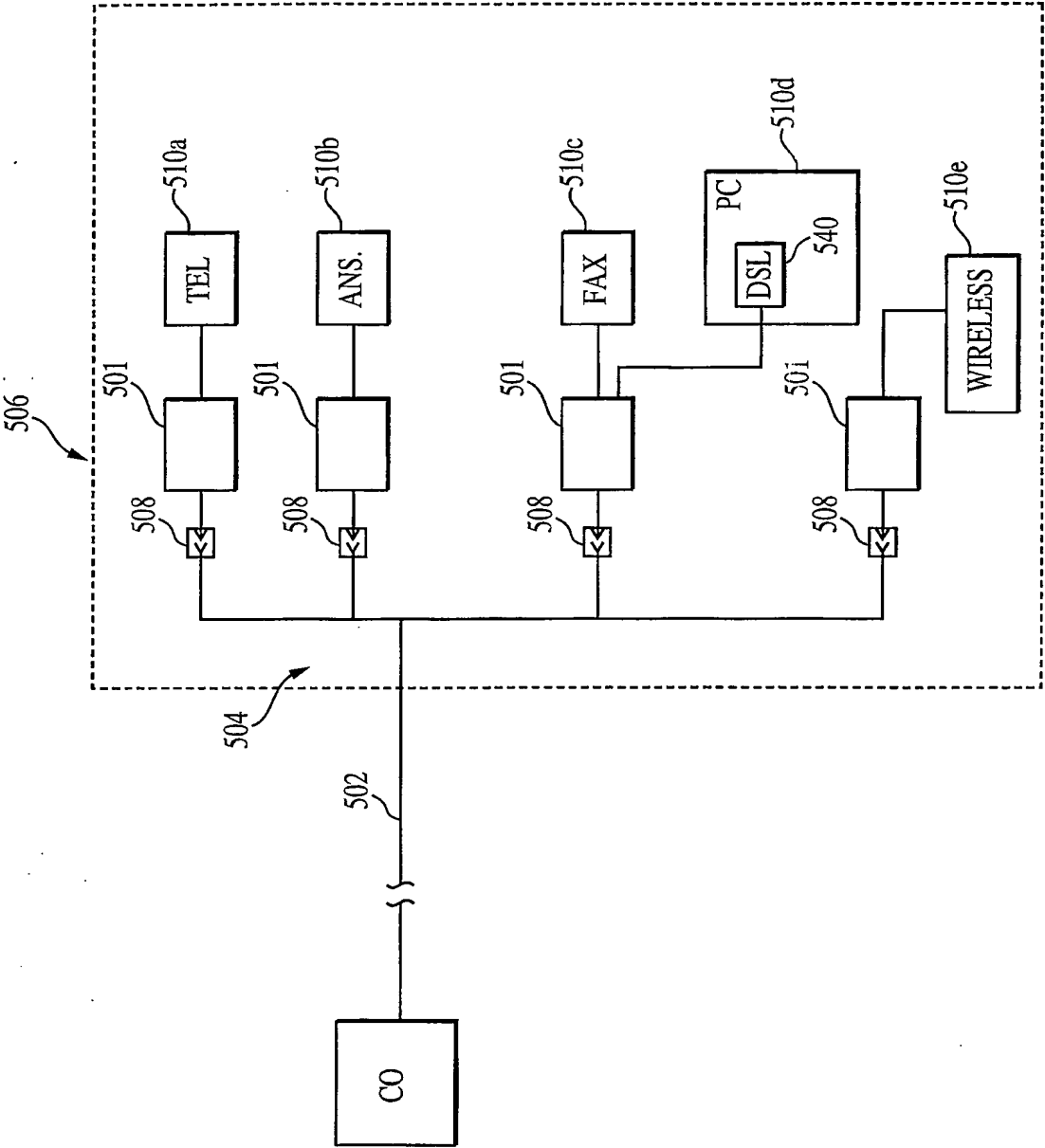


FIG. 5

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 01/45568

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04M11/06 H04L27/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04M H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 076 447 A (EXCELSUS TECHNOLOGIES INC) 14 February 2001 (2001-02-14) cited in the application	1,2,4-7, 9-11, 14-20, 24,25, 27,29, 32-34,37
Y	abstract  page 2, column 1, line 3 - line 11 page 2, column 2, line 15 - line 21 page 3, column 3, line 50 - line 53 page 4, column 5, line 28 - line 37; figure 1 page 4, column 6, line 32 - line 43 page 7, column 11, line 37 -column 12, line 25; figure 8 page 7, column 12, line 54 - line 58 -/--	3,8,21, 26,28, 31,35, 36,38



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

\* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the international search

7 January 2003

Date of mailing of the international search report

16/01/2003

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Bossen, M

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 01/45568

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>-----</p> <p>US 5 623 543 A (COOK JOHN W) 22 April 1997 (1997-04-22)</p> <p>column 4, line 54 - line 62; figure 4</p>	<p>3,8,21, 26,28, 31,35, 36,38</p>
X	<p>-----</p> <p>EP 0 677 938 A (BELL TELEPHONE MFG) 18 October 1995 (1995-10-18)</p> <p>page 2, column 1, line 19 - line 22 page 2, column 1, line 44 - line 58 page 3, column 3, line 18 - line 42</p> <p>-----</p>	<p>1,17,24, 27,32, 34,37</p>

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 12, 13, 22, 23, 30

Claims 12, 22 and 20 contain the feature generate a positive phase impedance. This feature is not explained in the description and unknown to the skilled artisan.

These claims are therefore not clear.

Claims 13 and 23 which depend on claims 12 resp. 13 are therefore also not clear.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 01/45568

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 12, 13, 22, 23, 30  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:  
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 01/45568

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1076447	A	14-02-2001	US 6181777 B1 30-01-2001
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			US 5627501 A 06-05-1997

## **WO03045043**

Publication Title:

HIGH PERFORMANCE MICRO-FILTER AND SPLITTER APPARATUS

Abstract:

Apparatus for conditioning and splitting telecommunications signals such as digital subscriber line (DSL) signals with improved stop band and return loss performance. In one aspect, the invention comprises an improved circuit having filter, impedance correction, and dynamic switching functionality suitable for more stringent application requirements (such as Europe). In one embodiment, the filter comprises a fourth-order elliptical filter coupled to an RLC impedance correction network. Dynamic switching is accomplished via a plurality of switch elements based on, e.g., filter current. In a second embodiment, a non-dynamic splitter with impedance correction and filter circuit is disclosed. Subscriber-end systems employing the foregoing signal conditioning and splitter circuits are also described.

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